Enemy Speed Control on Shoot em' Up Game with Fuzzy Takagi Sugeno Method

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***Abstract*—Shoot em' up game is one of the sub-genre of action game. This action game is attractive because the game play usually use the interesting user interface and easily affect human emotion. With the aim to eliminate all the enemy, this kind of game will be boredom the player if the enemy behavior are monotones. This game needs a controller to add dynamic system into the enemy such as the artificial intelligence. Therefore, this paper proposes Fuzzy Takagi Sugeno method that will take several input and give the response as the output. So, the game will manipulate the enemy behavior that make the game more challenging and interesting to be played.**

Keywords-component; Challenging Rate, Fuzzy Takagi Sugeno, Action Game, Artificial Intelligence (AI), and Aircraft Game

I. INTRODUCTION

Good games are expected not only to give pleasure to the players, but the game should also have other positive values. One of the positive side is it can be the development of the human brain performance [1]. The game itself is a system where players are involved in the regulation and the prevailing culture in it, the player interacts with the system and the conflict in the form of artificially engineering.

One of the genre of game is an action game. One of the subgenre of action game is the shoot 'em up [2]. Shoot em 'up is a shooting game that can be done between players to players or players with the artificial intelligence enemy. The purpose of this game is pretty simple, where player shoot all the enemies while try to survive from enemy attacks.

This project will be represented the space craft motion speed while they are airing in the field and keep trying to kill the player. To make the game more interesting, the enemies in the game shoot em 'up is given artificial intelligence so that the game is more challenging to solve especially the response time of the enemy itself [3]. It can be guessed when they shoot, evade and so on so this likely the player become an auto machine by just memorizing the time of the enemy behavior. Shoot em' up game is a game that will be designed to target the enemy with the help of artificial intelligence to control the level of difficulty.

Existing shoot em' up game need to have a control that makes the differences among gameplay scenario. Because the constant speed of the enemy in this game makes player easy to guess enemy motion. So, speed controller by an artificial intelligence is necessary to make player difficult to guess enemy motion.

One example of the artificial intelligence that can modify the game is the fuzzy method. The actual research that already uses the implementation of fuzzy method in a shoot em 'up is "the application of Intelligent Behavior in Object in Flash Tower Defense Game" (Penerapan Perilaku Cerdas pada Obyek di Dalam Game Flash Tower Defense) by algorithms fuzzy Nuvem[4].

Beside Fuzzy Nuvem, fuzzy Takagi - Sugeno also can be used to control enemy speed patterns that were given artificial intelligence in the game shoot em 'up with objects such as space craft. Due to is the ability to tune certain variables easily by varying the linguistic rules or input variables, the algorithm is suitable for use the advantage of fuzzy logic[5]. Fuzzy Takagi Sugeno use several parameters as the input for the game and then there will be a collection of an output depends on the parameters. This more suited as a nonlinear control system[6].

II. APPLIED TECHNIQUE

Fuzzy logic can make computer to reasoning about linguistic terms and rules like a human. To represent "wide" or "tight" of linguistic terms there will use the fuzzy set. The fuzzy set can be described as black, gray, and white. The fuzzy set enables values be assigned to set to a degree thing that called it fuzzification process. So, with fuzzied values, the computer can understand linguistic rules and make the output that consist of the fuzzy set to be defuzzified to give the crisp value[7].

Fuzzy set defined as a membership function. The function explains about the gradual transition from the region completely that on the outside within the set, so that enable a value to have partial membership in a set [7].

A. Fuzzy Linguistic Variable (FLV)

FLV is the composition of one or more fuzzy sets to represent a concept or domain qualitatively. In this process, there will determine the values that made a linguistic value of the input sets and the output sets that will proceed. And after that, there will start to make a membership function for each linguistic value. The collection of the membership function that comprise the FLV will be called as fuzzy manifold or fuzzy surface [7].

B. *Fuzzification*

Fuzzification is the process to change a crisp value in to the quantity fuzzy linguistic set or membership degree [8]. The interface of fuzzification will be explained by following steps [9]:

i. Measure input variable value
ii. Performs mapping scale that transfers range of input values into the variables in the corresponding universe of discourse
iii. Performs fuzzification that converts a crisp function into a corresponding linguistic variable so it can be viewed as fuzzy sets

C. *Fuzzy Rules*

Fuzzy rules advocated as key tool to express pieces of knowledge in “fuzzy logic”[10]. The antecedent describes a condition and the consequences the represents consequence if the condition is satisfied.

The difference with fuzzy rules from conventional rules where the consequent either fires or not, in fuzzy systems the consequent can fire to a matter of degree. The antecedent, can be found as a single fuzzy term or the set that is the result of a combination of several fuzzy terms. [7]

Each time a fuzzy system iterates through its rule set it combines the consequents that have fired and defuzzifies the result to give a crisp value.

D. *Fuzzy Evaluation and Fuzzy Aggregation*

This is the process where will present the system with some values to see which rules fire and to what degree. Fuzzy inference follows these steps:

1. For each rule,
   1. a. For each antecedent, calculate the degree of membership of the input data.
   1. b. Calculate the rule’s inferred conclusion based upon the values determined in 1.a.
2. Combine all the inferred conclusions into a single conclusion (a fuzzy set).
3. For crisp values, the conclusion from 2 must be defuzzified.

There are a few ways to handle multiple confidence. The two most used ways are bounded sum (sum and bound on one) and maximum value (equivalent to OR-ing all the confidences).

The next step is to combine the inferred results into a single fuzzy manifold. The outcome that will be obtained is the composite fuzzy set representing the inferred conclusion of all the rule base. The next step is going to process around and convert this output set into a single crisp value. This is can be acquired by a defuzzification process.

E. *Defuzzification*

Defuzzification is the process turning inference results into crisp value [11]. For fuzzy Takagi Sugeno use Weighted Average technique [12]. This method each output of the rule sets stored in the knowledge base of the system. The function of the weighted average defuzzification technique explained as (1):

$$x^* = \frac{\sum_{i=1}^{n} \; m^i w_i}{\sum_{i=1}^{n} \; m^i} \tag{1}$$

Where x^* is the defuzzified output, m^i is the each rule output membership, and w_i is the weight associated with each rule. This method is fast, easy and gives accurate result for the computerization process [13].

III. APPLYING THE FUZZY TAKAGI SUGENO

In this project model, fuzzy logic used to compute the enemy movement speed. As described in Figure 1, this control system shown relative simple. This fuzzy method will activate when the game starts. First of all, the method is embedded into every object the enemy space craft that will receive several inputs.

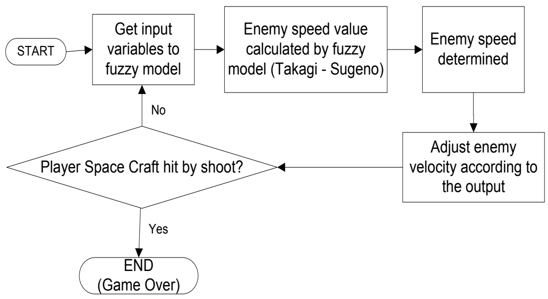
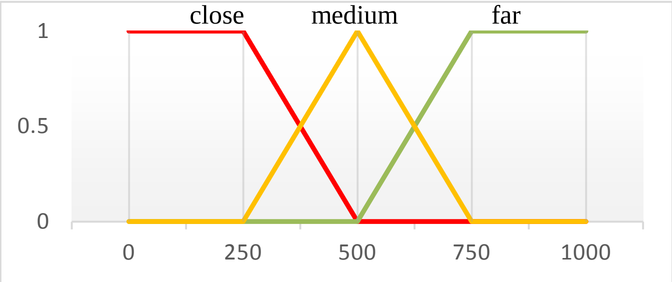


Figure 1. Fuzzy enemy speed control system

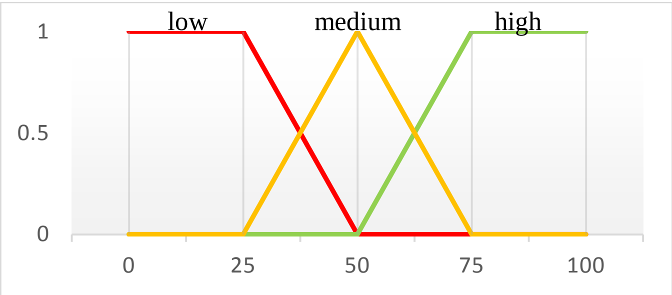
Input in this case is the distance, enemy Health Point and the rest are player remaining lives. Distance in this case is the form of the distance between the object space craft of the player space craft object. Then enemy health Point here refers to the rest of the health point which is owned by the enemy before the plane dispose. Then the last factor is the life remaining of the players in this game.

The output from this fuzzy process has one output variable. This value will determine the value of the speed of enemy space craft. After becoming crisp value, this value has become a value to determine the speed of the enemy. The enemy speed value which has three different linguistic values. For example, the three linguistic values are slow, medium, and fast.

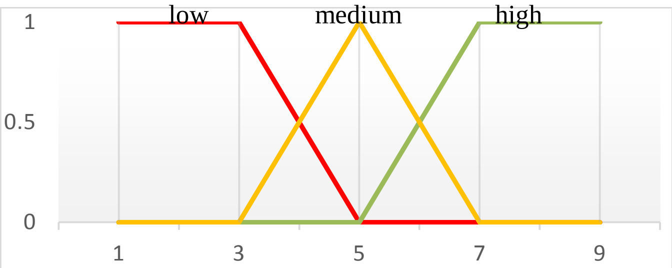
The desired system behavior of the enemy speed can be defined through the rules and the FLV. The fuzzy sets variables and their ranges as illustrated in Figure 2



Input variable "distance (m)"



Input variable "enemy health point (%)"



Input variable "remaining player life"

Figure 2. Membership function and their input variables

Distance: The distance between the enemy and the player varies from 0 to 1000 meters. A distance between 0 and 250 meters is considered as definitely close whereas a distance between 750 and 1000 meters is considered as definitely far.

Enemy Health Point (HP): The enemy health point bar are varies from 0% to 100%. Low amount of health point described between 0% and 25% is considered as definitely low and the health point between 75% and 100% is considered as definitely high.

Player Remaining Life: The player remaining life are varies from 1 to 5. If the player have the remaining life between 1 and 2 is considered as definitely low and the remaining life between 4 and 5 is considered as definitely high.

Enemy Speed: only use three linguistic that distinguish the enemy speed: *fast, medium, slow*. In this paper each value is by increment of 2.25 (slow = 3.25, medium = 5.5, fast = 7.75).

Table 1 is the list of the sixteen rules that will be implemented into the model. Note that these rules have been set up without any particular expert knowledge.

TABLE 1. LIST OF THE FUZZY IF-THEN RULES

R1:	IF distance is close and enemy HP is low THEN enemy speed is fast
R2:	IF distance is close and enemy HP is high THEN enemy speed is medium
R3:	IF distance is medium or enemy HP is low THEN enemy speed is slow
R4:	IF distance is medium or enemy HP is high THEN enemy speed is medium
R5:	IF distance is far and enemy HP is THEN low enemy speed is slow
R6:	IF distance is near or player remaining life is low THEN enemy speed is fast
R7:	IF distance is near or player remaining life is medium THEN enemy speed is fast
R8:	IF distance is medium and player remaining life is low THEN enemy speed is fast
R9:	IF distance is medium or player remaining life is medium THEN enemy speed is medium
R10:	IF distance is medium or player remaining life is high THEN enemy speed is slow
R11:	IF distance is far or player remaining life is high THEN enemy speed is slow
R12:	IF enemy HP is low and player remaining life is low THEN enemy speed is fast
R13:	IF enemy HP is low or player remaining life is high THEN enemy speed is slow
R14:	IF enemy HP is medium and player remaining life is high THEN enemy speed is slow
R15:	IF enemy HP is high or player remaining life is low THEN enemy speed is fast
R16:	IF enemy HP is high or player remaining life is medium THEN enemy speed is medium

When the enemy motion speed already computed using these input, the motion speed value of the enemy space craft will be adjusted accordingly. With that speed, the enemy will move closer to the player space craft while they shoot it. If the enemy fails to shoot the target space craft, the operator will modify the input and try again until they shoot the player or they pass the player space craft.

To apply the fuzzy to the game, the first step is to identify where the method to be placed. There are a variety of scripts that set the control of the game. One of them is a script to set the direction or speed of enemy movement. Through this script this method will be embedded.

The second step is to design the rule of this technique. The Fuzzy Takagi Sugeno method is executed in the game in progress. The input will be analyzed and taken each time the frame change. After the process of defuzzification, the speed of the enemy will be modified.

After that, the third step will talk about the game development. This game will use C# code that provided by Unity. Another code except the Fuzzy Takagi Sugeno is just about general script of game.

The lastly step is to integrate the method to the script. The logic that has been developed is imported to the game script so the game can compile the method when we play the game.

IV. Fuzzy Reasoning

In this paper, using the AND operation and the OR operation. The AND operation is the minimum value of the membership values. The OR operation is the maximum value of the membership values.[12]. As described before the defuzzification method is using weighted average method. For example, the input will be set as following:

Distance: 572 meters
Enemy HP: 73 %
Remaining Player Life: 4

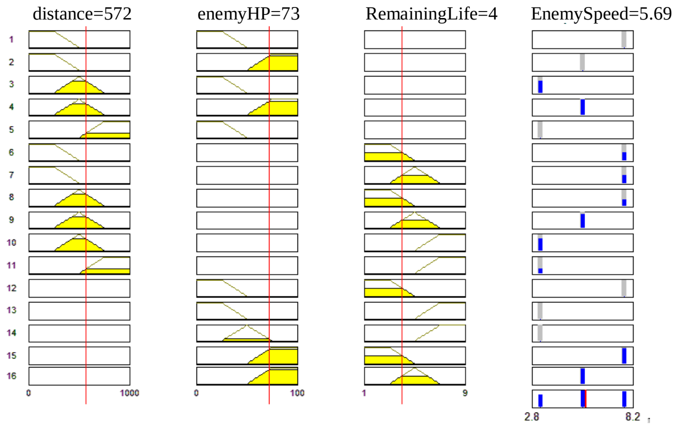


Figure 3. Diagram showing Takagi-Sugeno style rule evaluation, aggregation and defuzzification

After all the input is entered, from the process of the evaluation as figure 3 and then defuzzification for all singleton value is calculated by the previous function, we will get 5.69 m/s.

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